U. S. DEPARTMENT OF COMMERCE

BUILDING MATERIALS AND STRUCTURES

REPORT BMS86

Structural, Heat-Transfer, and Water-Permeability Properties of "Speedbrik" Wall Construction Sponsored by the General Shale Products Corporation

by

MAHLON F. PECK

VINCENT B. PHELAN

RICHARD S. DILL, *and*

PERRY H. PETERSEN

NATIONAL BUREAU OF STANDARDS

BUILDING MATERIALS AND STRUCTURES REPORTS

On request, the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., will place your name on a special mailing list to receive notices of new reports in this series as soon as they are issued. There will be no charge for receiving such notices.

An alternative method is to deposit with the Superintendent of Documents the sum of $5, with the request that the reports be sent to you as soon as issued, and that the cost thereof be charged against your deposit. This will provide for the mailing of the publications without delay. You will be notified when the amount of your deposit has become exhausted.

If 100 copies or more of any report are ordered at one time, a discount of 25 percent is allowed. Send all orders and remittances to the *Superintendent of Documents, U. S. Government Printing Office, Washington, D. C.*

The following publications in this series are available by purchase from the Superintendent of Documents at the prices indicated:

BMS1	Research on Building Materials and Structures for Use in Low-Cost Housing	10¢
BMS2	Methods of Determining the Structural Properties of Low-Cost House Constructions	10¢
BMS3	Suitability of Fiber Insulating Lath as a Plaster Base	10¢
BMS4	Accelerated Aging of Fiber Building Boards	10¢
BMS5	Structural Properties of Six Masonry Wall Constructions	15¢
BMS6	Survey of Roofing Materials in the Southeastern States	15¢
BMS7	Water Permeability of Masonry Walls	10¢
BMS8	Methods of Investigation of Surface Treatment for Corrosion Protection of Steel	10¢
BMS9	Structural Properties of the Insulated Steel Construction Co.'s "Frameless-Steel" Constructions for Walls, Partitions, Floors, and Roofs	10¢
BMS10	Structural Properties of One of the "Keystone Beam Steel Floor" Constructions Sponsored by the H. H. Robertson Co	10¢
BMS11	Structural Properties of the Curren Fabrihome Corporation's "Fabrihome" Constructions for Walls and Partitions	10¢
BMS12	Structural Properties of "Steelox" Constructions for Walls, Partitions, Floors, and Roofs Sponsored by Steel Buildings, Inc	15¢
BMS13	Properties of Some Fiber Building Boards of Current Manufacture	10¢
BMS14	Indentation and Recovery of Low-Cost Floor Coverings	10¢
BMS15	Structural Properties of "Wheeling Long-Span Steel Floor" Construction Sponsored by the Wheeling Corrugating Co	10¢
BMS16	Structural Properties of a "Tilecrete" Floor Construction Sponsored by Tilecrete Floors, Inc	10¢
BMS17	Sound Insulation of Wall and Floor Constructions	10¢
Supplement to BMS17, Sound Insulation of Wall and Floor Constructions		5¢
BMS18	Structural Properties of "Pre-Fab" Constructions for Walls, Partitions, and Floors Sponsored by the Harnischfeger Corporation	10¢
BMS19	Preparation and Revision of Building Codes	15¢
BMS20	Structural Properties of "Twachtman" Constructions for Walls and Floors Sponsored by Connecticut Pre-Cast Buildings Corporation	10¢
BMS21	Structural Properties of a Concrete-Block Cavity-Wall Construction Sponsored by the National Concrete Masonry Association	10¢
BMS22	Structural Properties of "Dun-Ti-Stone" Wall Construction Sponsored by the W. E. Dunn Manufacturing Co	10¢
BMS23	Structural Properties of a Brick Cavity-Wall Construction Sponsored by the Brick Manufacturers Association of New York, Inc	10¢
BMS24	Structural Properties of a Reinforced-Brick Wall Construction and a Brick-Tile Cavity-Wall Construction Sponsored by the Structural Clay Products Institute	10¢
BMS25	Structural Properties of Conventional Wood-Frame Constructions for Walls, Partitions, Floors, and Roofs	15¢
BMS26	Structural Properties of "Nelson Pre-Cast Concrete Foundation" Wall Construction Sponsored by the Nelson Cement Stone Co., Inc	10¢
BMS27	Structural Properties of "Bender Steel Home" Wall Construction Sponsored by The Bender Body Co	10¢
BMS28	Backflow Prevention in Over-Rim Water Supplies	10¢
BMS29	Survey of Roofing Materials in the Northeastern States	10¢
BMS30	Structural Properties of a Wood-Frame Wall Construction Sponsored by the Douglas Fir Plywood Association	10¢

List continued on cover page III]

UNITED STATES DEPARTMENT OF COMMERCE · Jesse H. Jones, Secretary

NATIONAL BUREAU OF STANDARDS · Lyman J. Briggs, Director

BUILDING MATERIALS *and* STRUCTURES

REPORT BMS86

Structural, Heat-Transfer, and Water-Permeability
Properties of "Speedbrik" Wall Construction
Sponsored by the General Shale Products Corporation

by MAHLON F. PECK, VINCENT B. PHELAN, RICHARD S. DILL
and PERRY H. PETERSEN

ISSUED JULY 15, 1942

The National Bureau of Standards is a fact-finding organization; it does not "approve" any particular material or method of construction. The technical findings in this series of reports are to be construed accordingly

UNITED STATES GOVERNMENT PRINTING OFFICE · WASHINGTON · 1942

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, WASHINGTON, D. C. · PRICE 15 CENTS

Foreword

This report is one of a series issued by the National Bureau of Standards on the properties of constructions intended for low-cost houses and apartments. These constructions were sponsored by organizations within the building industry advocating and promoting their use. The sponsor built and submitted the specimens described in this report for the program outlined in BMS2. The sponsor, therefore, is responsible for the design of the construction and for the description of materials and methods of fabrication. The Bureau is responsible for the testing of the specimens and the preparation of the report.

This report covers the load-deformation relations and strength of the structural elements submitted when subjected to compressive, transverse, concentrated, impact, and racking loads; heat-transfer coefficients determined in a shielded hot-box heat-transfer apparatus; and water-permeability values obtained by tests under conditions that simulated exposure to a heavy wind-driven rain.

The National Bureau of Standards does not "approve" a construction, nor does it express an opinion as to its merits, for reasons given in reports BMS1 and BMS2. The technical facts presented in this series provide the basic data from which architects and engineers can determine whether a construction meets desired performance requirements.

Lyman J. Briggs, *Director.*

Structural, Heat-Transfer, and Water-Permeability Properties of "Speedbrik" Wall Construction Sponsored by the General Shale Products Corporation

by MAHLON F. PECK, VINCENT P. PHELAN, RICHARD S. DILL, *and* PERRY H. PETERSEN

CONTENTS

ABSTRACT

For the program on the investigation of low-cost house constructions, specimens representing "Speedbrik" masonry wall construction were submitted by the General Shale Products Corporation. These specimens were subjected to structural, heat-transfer, and water-permeability tests.

The structural specimens were subjected to compressive, transverse, concentrated, impact, and racking loads, for each of which three like specimens were tested. The transverse, concentrated, and impact loads were applied to the inside face of the specimens.

The deformation under load and the set after the load was removed were measured for each increment of load.

Heat-transfer properties of two specimens were determined in a shielded hot-box heat-transfer apparatus.

Nine water-permeability specimens were tested under conditions that simulated exposure to a heavy wind-driven rain.

I. INTRODUCTION

To provide technical facts on the performance of constructions for low-cost houses, to discover promising new constructions, and ultimately to determine the properties necessary for acceptable performance in actual service, the National Bureau of Standards has invited the cooperation of the building industry in a program of research on building materials and structures suitable for low-cost houses and apartments. The objectives of this program are described in BMS1, Research on Building Materials and Structures for Use in Low-Cost Housing.

To determine the strength of house constructions in the laboratory, standardized methods were developed for applying loads to portions of a completed house. Included in this study were masonry and wood-frame constructions of

types which have been extensively used in this country for houses and whose behavior under widely different service conditions is well known to builders and the public. The reports on these constructions are BMS5, Structural Properties of Six Masonry Wall Constructions, and BMS25, Structural Properties of Conventional Wood-Frame Constructions for Walls, Partitions, Floors, and Roofs. The masonry specimens were built by the Masonry Construction Section of this Bureau, and the wood-frame specimens were built and tested by the Forest Products Laboratory at Madison, Wis.

This report describes the structural, heat-transfer, and water-permeability properties of a wall construction sponsored by one of the manufacturers in the building industry. The structural specimens were subjected to compressive, transverse, concentrated, impact, and racking loads, simulating the loads to which the walls of a house are subjected.

In actual service, compressive loads on a wall are produced by the weight of the roof, second floor, and second-story walls, if any; by furniture and occupants; and by snow and wind loads on the roof. Transverse loads on a wall are produced by wind, concentrated and impact loads by accidental contact with heavy objects, and racking loads by the action of the wind on adjoining walls.

The deflection and set under each increment of load were measured, because the suitability of a construction depends not only on its resistance to deformation when loads are applied but also on its ability to return to its original size and shape when the loads are removed.

Two specimens were subjected to heat-transfer tests, during which the temperature of the air near the outside surface was maintained at 0° F and that near the inside surface at 70° F to simulate conditions which might exist in actual service.

Nine specimens were exposed in the water-permeability test chamber to conditions similar to a heavy wind-driven rain.

II. SPONSOR AND PRODUCT

The specimens were submitted by the General Shale Products Corporation, Kingsport, Tenn., with the cooperation of the Structural Clay Products Institute and the Speedbrik Corporation, and represented a masonry wall construction of "Speedbrik" units.

III SPECIMENS AND TESTS

1. Structural

The wall construction for the structural-property tests was assigned the symbol *DP*, and the individual specimens were assigned the designations given in table 1.

Table 1.—*Specimen designations, wall DP*

Specimen designation	Load	Load applied
C1, C2, C3	Compressive	Upper end.
T1, T2, T3	Transverse	Inside face.
P1, P2, P3 [a]	Concentrated	Do.
I1, I2, I3	Impact	Do.
R1, R2, R3	Racking	Near upper end.

[a] The transverse and concentrated loads were applied to the same specimens, the transverse loads first.

Except as mentioned below, the specimens were tested in accordance with BMS2. That report also gives the requirements for specimens and describes the presentation of the results of the tests, particularly the load-deformation graphs.

For the transverse, concentrated, and impact loads there were only three specimens for each load, not six as required by BMS2. This construction was symmetrical about a plane midway between the faces, except that there was a shallow groove in the outside face filled with mortar and the mortar joints on the outside face were tooled; therefore the results for loads applied to one face of the specimen were assumed to be practically the same as those for loads applied to the other face.

Under compressive load the shortenings and sets were measured with compressometers attached to the steel plates through which the load was applied, not attached to the specimen as described in BMS2.

Lateral deflections under compressive and transverse loads were measured with a deflectometer of fixed gage length, which consisted of a light (duralumin) tubular frame having a leg at one end and a hinged plate at the other. The deflectometer was attached near the upper end of a face of the specimen by clamping the

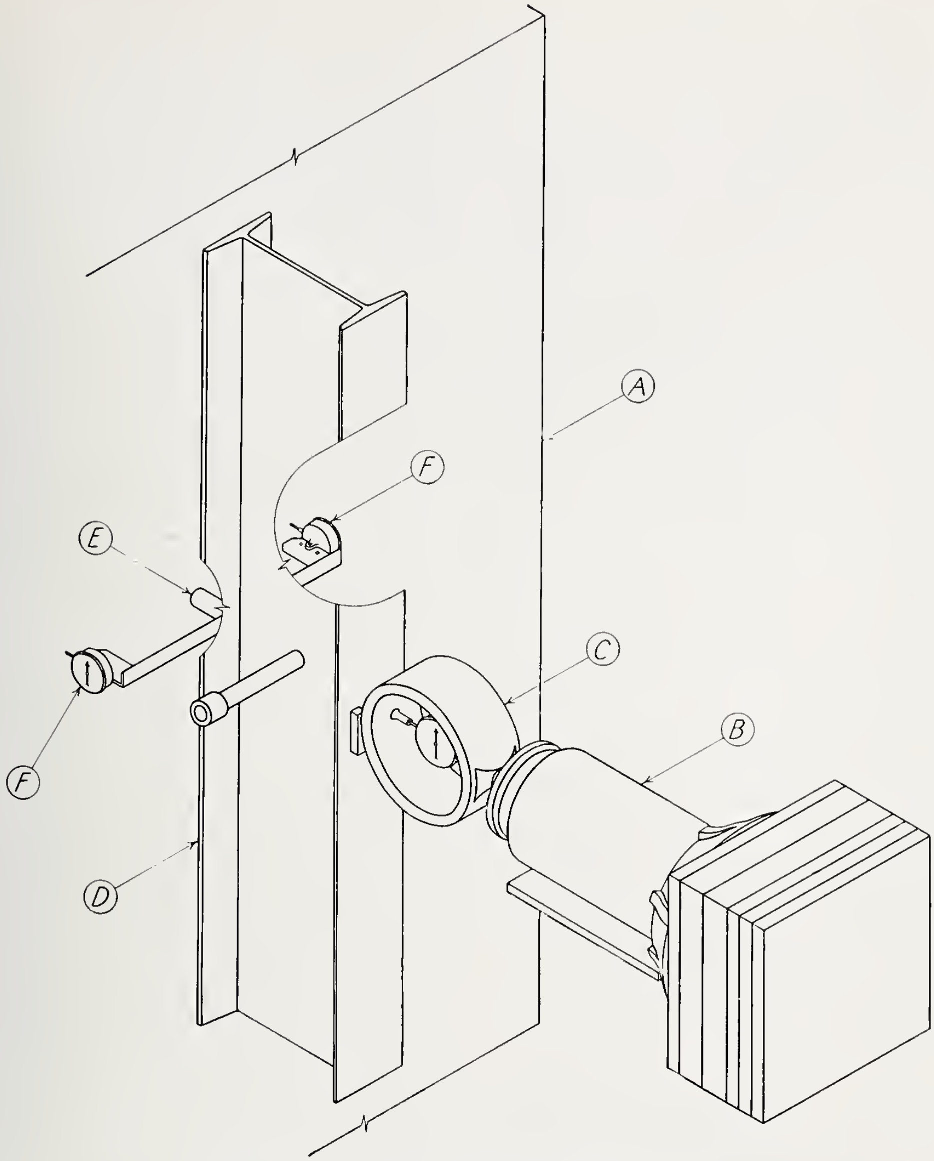


FIGURE 1.—*Apparatus for concentrated-load test.*

A, specimen; *B*, hydraulic jack; *C*, ring dynamometer; *D*, beam; *E*, steel disk; *F*, dial micrometer.

hinged plate. The gage length (distance between points of support) was 7 ft. 6 in. A dial micrometer was attached to the frame at midlength, with its spindle in contact with the specimen. The dial was graduated to 0.001 in., and readings were recorded to the nearest division. Two deflectometers were attached to the specimen, one near each edge. This method of measurement was used instead of the taut-wire mirror-scale device described in BMS2.

The indentation under concentrated load and the set after the load was removed were measured, not the set only, as described in BMS2. The apparatus is shown in figure 1. Specimen *A* was vertical, as for the transverse test. The load was applied by a jack, *B*, through a ring dynamometer (load-measuring device), *C*, to a freely movable steel beam, *D*, to which were attached a thick steel disk, *E*, and two dial micrometers, *F*. One end of the disk and the spindles of the micrometers were in contact with the face of the specimen. The distance between the spindles was 16 in. The dials were graduated to 0.001 in., and readings

were recorded to the nearest tenth of a division. A small initial load was applied to prevent shifting of the disk, and the average of the micrometer readings was taken as the initial reading. Greater loads were applied, and the average of the micrometer readings minus the initial reading was taken as the depth of the indentation under load. The set after the load was reduced to the initial value was determined in the same manner.

The deformations under racking load were measured with a right-angle deformeter, consisting of a steel channel and a steel angle braced to form a rigid connection. The channel rested on two steel plates, ½ in. thick and 4 in. square, on top of the specimen, with the steel angle extending downward in the plane of the specimen. A dial micrometer was attached to the lower end of the angle, its spindle being in contact with the edge of the specimen. The gage length (distance from the top of the specimen to the spindle) was 6 ft. 11 in. The dial was graduated to 0.001 in., and readings were recorded to the nearest tenth of a division. This deformeter was used instead of the taut-wire mirror-scale device described in BMS2.

The tests were begun May 14, 1941, and completed May 28, 1941. With one exception, the specimens were tested on the 28th day after they were built. Compressive specimen *C3* was tested on the 29th day. The sponsor's representative witnessed the tests.

2. Heat-Transfer

The specimens for the determination of the heat-transfer properties were assigned the symbols *HT51* and *HT52*.

The heat-transfer properties were determined by the shielded hot-box method. The tests were begun May 26, 1941, and completed June 6, 1941. Specimens *HT51* and *HT52* were tested 34 and 39 days, respectively, after being built.

3. Water-Permeability

Three of the nine water-permeability specimens were similar to structural specimens *DP*, and all were aged at least 1 month before being tested. The other six specimens were constructed in January 1939, five of which were of 8-in. units, and the sixth was of 4- and 8-in. units arranged to form a specimen 12 in. thick.

The units were manufactured by the Claycroft Co., Columbus, Ohio, and the General Shale Products Co., Kingsport, Tenn. Three different mortars were used, but the workmanship, test procedure, and method of rating were the same in all specimens.

IV. STRUCTURAL PROPERTIES

1. Materials

Unless otherwise stated, the information on materials was obtained from the sponsor and by inspection of the specimens. The Masonry Construction Section of the National Bureau of Standards determined the physical properties of the masonry units and the mortar and obtained the fabrication data.

(a) *Masonry Units*

Side-cut shale units. The nominal dimensions of the units shown in figure 2 were 5¾ in. thick, 11 ^15^⁄~16~ in. wide, and 2¾ in. long. They were of double-shell construction with six major cells. On the face of the unit a groove ⅜ in. wide by ⅜ in. deep gave the appearance of Flemish bond to the wall after the groove had been filled with mortar.

The nominal dimensions of the half units were 5¾ in. thick, 6 in. wide, and 2¾ in. long. They were like full-sized units divided at midwidth. The physical properties of the units are given in table 2.

Table 2.—*Physical properties of masonry units, wall DP*

Property	Unit	Half unit
Average dimensions:		
Thickness ... in.	5.72	5.72
Width ... in.	11.95	5.84
Length ... in.	2.73	2.74
Over-all thickness of outer shell ... in.	1.62	1.58
Average dry weight ... lb	9.09	4.39
Absorption:		
By total immersion:		
5-hr cold ... % by dry weight	2.8	2.9
24-hr cold, *C* ... % by dry weight	3.4	3.3
5-hr boil, *B* ... % by dry weight	7.0	6.6
By partial immersion: [a]		
When laid ... g/30 in.²	21.0	...
Saturation coefficient, *C/B*	0.49	0.53
Compressive strength:		
Net area ... lb/in.²	9,420	9,900
Gross area ... lb/in.²	5,860	6,090
Transverse strength, 10-in. span ... lb/in.²	1,465	...

[a] Immersed on flat side in ⅛ in. of water for 1 minute.

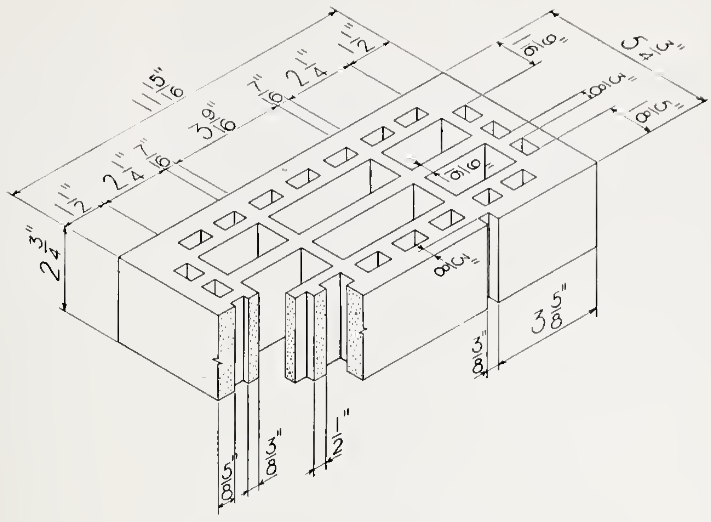


FIGURE 2.—*Masonry unit.*

(*b*) *Mortar*

(1) *Cement.*—The cement was Green Bag Portland Cement Co.'s "Green Bag" portland cement. It complied with the requirements of Federal Specification SS–C–191a for soundness, time of set, fineness, and tensile strength.

(2) *Lime.*—The lime was M. J. Grove Co.'s "Frederick County Mason's Hydrated Lime." The plasticity of the lime, determined in accordance with Federal Specification SS–L–351, was 170.

(3) *Sand.*—The sand was Potomac River building sand. The sieve analysis is given in table 3.

TABLE 3.—*Sieve analysis of the sand, wall DP*

U. S. Standard Sieve No.	Passing, by weight
	Percent
8	100
16	100
30	86
50	47
100	16

(4) *Mix.*—The mortar proportions were, by weight, 1 part of portland cement, 0.42 part of hydrated lime, and 5.1 parts of dry sand; by volume, 1 part of portland cement, 1 part of hydrated lime, and 6 parts of loose, damp sand, assuming that portland cement weighs 94 lb/ft^3, dry hydrated lime weighs 40 lb/ft^3, and that 80 lb of dry sand is equivalent to 1 ft^3 of loose, damp sand. The materials for each batch of mortar were measured by weight and mixed in a batch mixer having a capacity of ⅔ ft^3. The amount of water added was adjusted to the satisfaction of the mason and was 21.0 percent of the dry materials, by weight.

Samples of the mortar were taken from at least one batch for each wall, the flow before and after suction was determined in accordance with Federal Specification SS–C–181b, Cement; Masonry, and six 2-in. cubes were made. The average flow of the mortar was 120 percent, and the ratio of the flow after suction to the initial flow was 65 percent. Three cubes were stored in water at 70° F. and three stored in air near the specimens. The strength of the mortar is given in table 4.

TABLE 4.—*Average compressive strength of mortar, wall DP*

[Determined on the day the corresponding wall specimen was tested]

Specimen	Compressive strength	
	Water storage	Air storage
	lb/in.^{2}	*lb/in.*^{2}
C1	900	435
C2	840	480
C3	800	505
T1	975	645
T2	790	455
T3	900	610
I1	1,015	650
I2	870	455
I3	840	470
R1	855	610
	835	605
R2	785	390
	720	380
R3	760	330
	730	305
Average	840	490

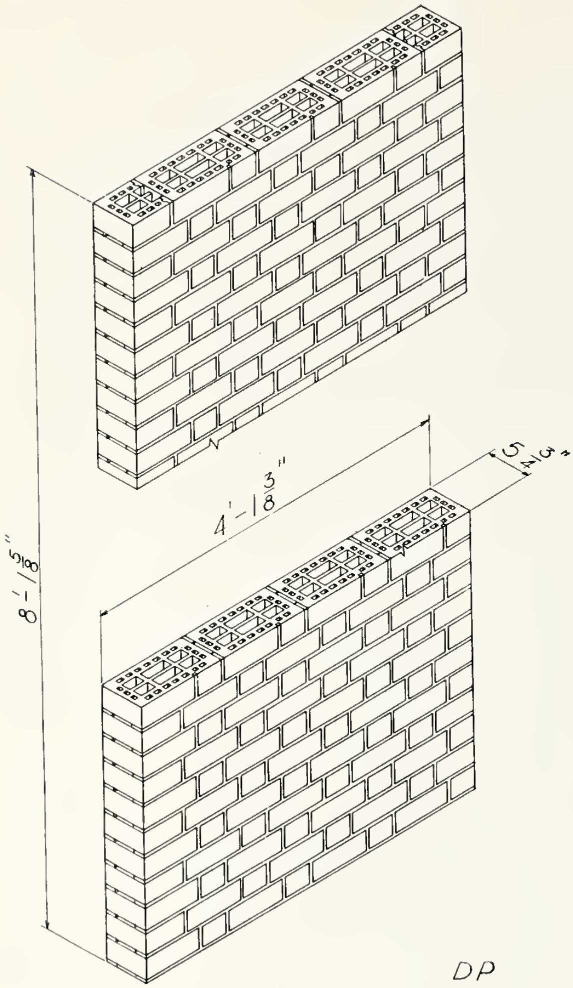


Figure 3.—*Four-foot wall DP.*

(c) *Fabrication Data*

Fabrication data for wall *DP* are given in table 5.

Table 5.—*Fabrication data, wall DP*

[The values per square foot were computed using the face area of the specimens]

Joint thickness:		
Bed	in	0.52
Head	in	.47
Masonry units	No./ft^2	3.59
Portland cement	lb/ft^2	1.51
Lime hydrate	lb/ft^2	0.635
Sand, dry	lb/ft^2	7.71
Mason's time:		
Laying units	hr/ft^2	0.069
Pointing and tooling	hr/ft^2	.013
Total	hr/ft^2	.082

2. Sponsor's Statement

Wall *DP* was masonry built of cellular shale units. The units and mortar were exposed on both faces.

The price of this construction in Washington, D. C., as of July 1937, was \$0.35/ft^2.

(a) *Description of Specimens, Wall DP*

(1) *Four-foot specimens.*—The average dimensions of the specimens which are shown in figure 3 were: height, 8 ft 1⅝ in.; width 4 ft 1⅜ in.; thickness, 5¾ in. There were 30 courses of units in each 4-ft specimen, with 4 units, or the equivalent, in each course.

The inside face of specimen *DP–R3* during construction is shown in figure 4. The units were dry when received and were laid without wetting. Mortar for the bed joint was placed only on the front and back shells of the units. for the head joints, the ends of the units were buttered, and when laid the joint extended only the thickness of the front and back shells. The grooved faces of the units were the outside face of the specimen, which was plumbed. The grooves were filled with mortar to give the appearance of a joint, and all the joints were tooled to a concave surface.

The outside face of the specimens had the appearance of Flemish bond.

The specimens were built by an experienced mason.

(2) *Eight-foot specimens.*—The 8-ft specimens, shown in figure 5, were similar to the 4-ft specimens. The average dimensions were: height 8 ft 1⅝ in.; width, 8 ft 2$^{11}/_{16}$ in.; thickness, 5¾ in. There were 30 courses of units in each 8-ft specimen, with 8 units, or the equivalent, in each course. Mortar was placed in the cells in one unit, or the equivalent, in one end of the four upper courses and in the four lower courses at the diagonally opposite corner. These cells were filled to prevent local crushing where the racking load was applied and at the stop.

3. Compressive Load

Specimen *DP–C2* under compressive load is shown in figure 6. The results for specimens *DP–C1*, *C2*, and *C3* are shown in table 6 and in figures 7 and 8.

The speed of the movable head of the testing machine was adjusted to 0.044 in./min.

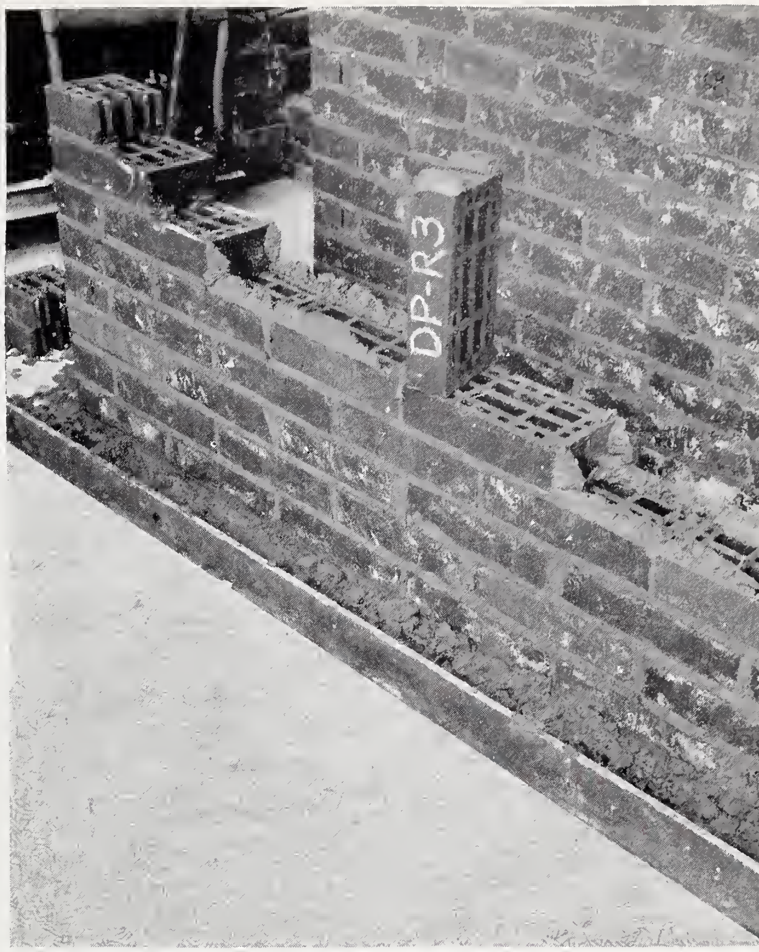


FIGURE 4.—*Wall specimen DP–R3 during construction.*

TABLE 6.—*Structural properties, wall DP*

[Weight, based on face area: 41.37 lb/ft ²]

Compressive load [a]		Transverse load; span, 7 ft 6 in.		Concentrated load; disk, diam 1 in.		Impact load; spau, 7 ft 6 in.; sandbag, 60 lb		Racking load	
Specimen	Maximum load	Specimen	Maximum load	Specimen	Maximum load	Specimen	Maximum height of drop	Specimen	Maximum load
	[b] *Kips/ft*		*lb/ft²*		*lb*		*ft*		[b] *Kips/ft*
C1	49.33	*T1*	26.06	*P1*	[c] 1,000	*I1*	1.0	*R1*	3.22
C2	41.32	*T2*	27.18	*P2*	[c] 1,000	*I2*	1.0	*R2*	3.57
C3	39.86	*T3*	23.42	*P3*	[c] 1,000	*I3*	1.5	*R3*	3.27
Average	43.50	Average	25.55	Average	[c] 1,000	Average	1.2	Average	3.35

[a] Load applied 1.92 in. (one-third the thickness of the specimen) from the inside face.

[b] A kip is 1,000 lb.

[c] Test discontinued. Specimen undamaged.

Under a load of 43 kips/ft on *DP–C1*, vertical cracks appeared in both edges of the specimen in the four lower courses near midthickness. Under the maximum load, these cracks extended one-fourth the height of the specimen. Vertical cracks appeared near midthickness in the two upper courses of specimen *C3* under a load of 28 kips/ft. Under the maximum load on specimens *C2* and *C3*, the mortar spalled from the bed joints on the upper half of the inside face, Although no cracks were visible in specimen *C2* after test, removal of the upper courses showed cracks in the webs of the three upper courses.

463397°—42——2

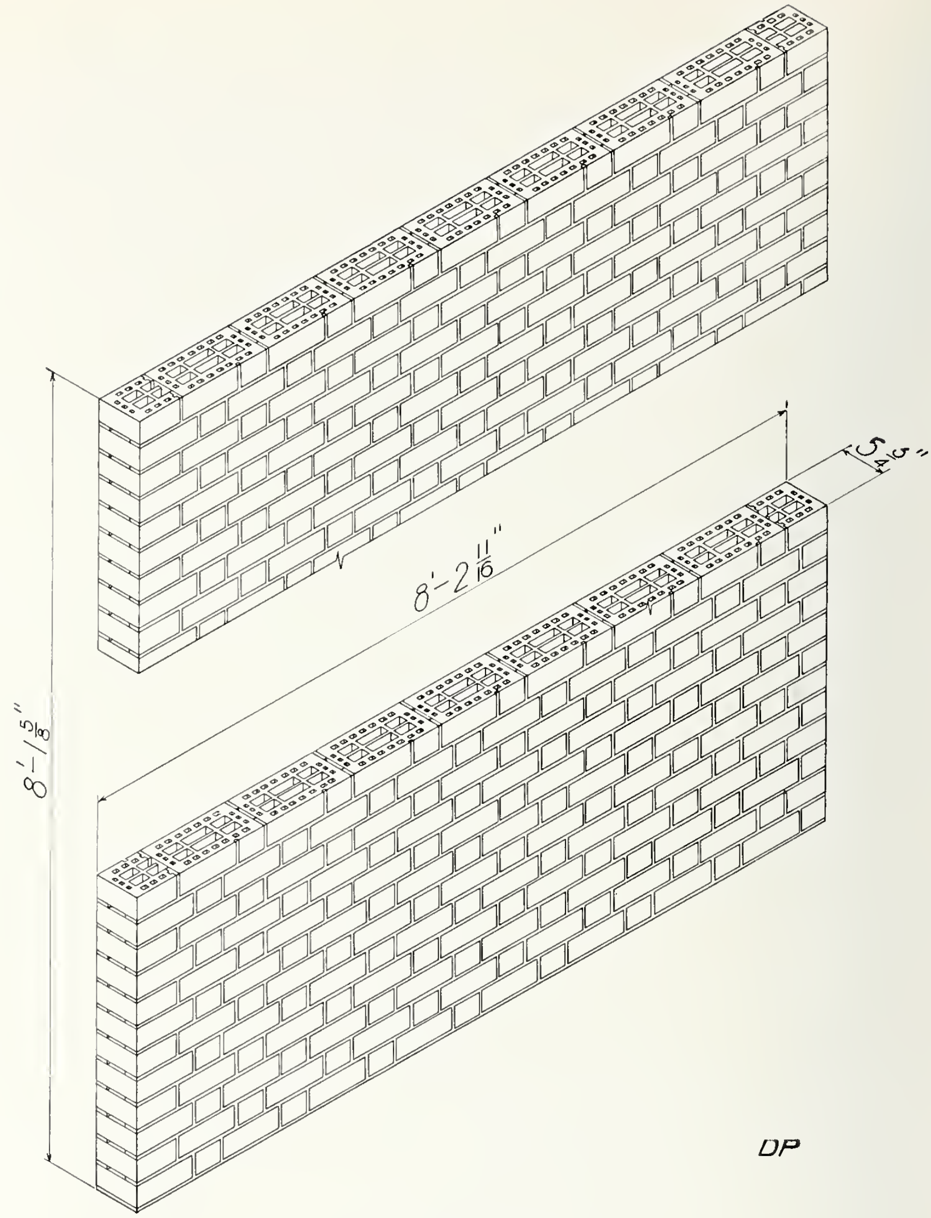


FIGURE 5.—*Eight-foot wall DP.*

4. Transverse Load

Wall specimen *DP–T2* under transverse load is shown in figure 9. The results for wall specimens *DP–T1*, *T2*, and *T3* are shown in table 6 and in figure 10. Under the maximum load on each specimen, one bed joint near the upper loading roller ruptured between the units and the mortar, the crack extending the entire width and thickness of the specimen.

5. Concentrated Load

The results of the concentrated load on specimens *DP–P1*, *P2*, and *P3* are shown in table 6 and in figure 11.

The load was applied to a unit near the center of the specimen. The sets after a load of 1,000 lb had been applied to specimens *P1*, *P2*, and *P3* were 0.000, 0.009, and 0.001, respectively. No other effects were observed.

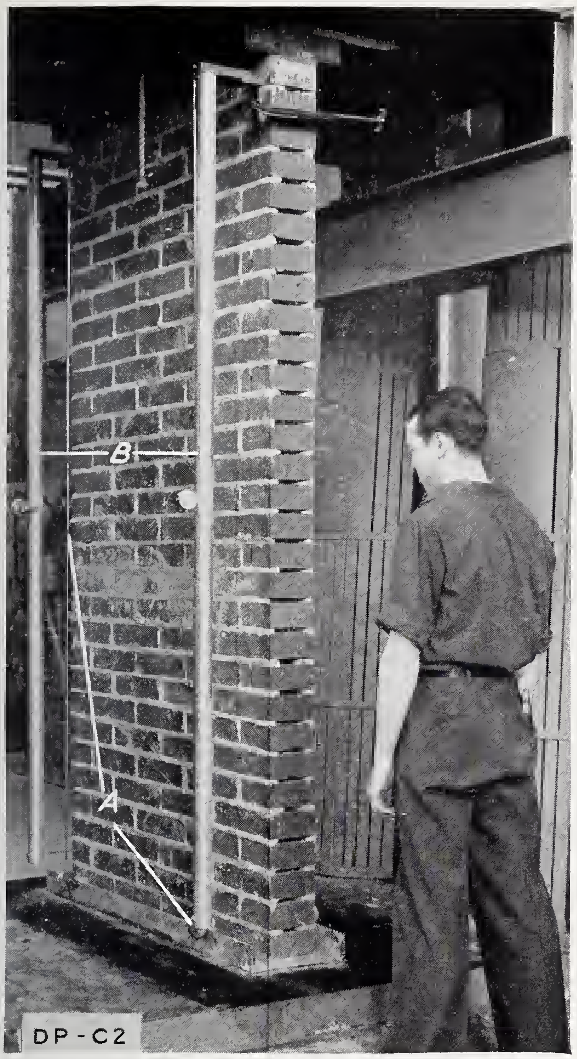


FIGURE 6.—*Wall specimen DP–C2 under compressive load.*

A, compressometer; *B*, deflectometer.

6. Impact Load

Specimen *DP–I1* during the impact test is shown in figure 12. The results of the impact loads on specimens *DP–I1*, *I2*, and *I3* are shown in table 6 and in figure 13.

At a drop of 0.5 ft on specimens *DP–I1* and *I2*, a bed joint near midheight cracked between the units and the mortar, beginning at the face not loaded and extending the width of the specimen, but not through the thickness. Specimen *I3* cracked in the same way at a drop of 1.0 ft. After the maximum height of drop, the cracks extended through the entire thickness of each specimen.

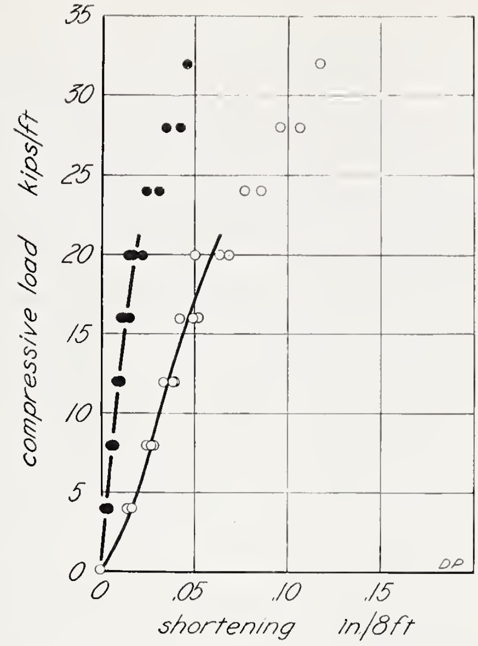


FIGURE 7.—*Compressive load on wall DP.*

Load-shortening (open circles) and load-set (solid circles) results for specimens *DP–C1*, *C2*, and *C3*. The load was applied 1.92 in. (one-third the thickness of the wall) from the inside face. The loads are in kips per foot of actual width of specimen.

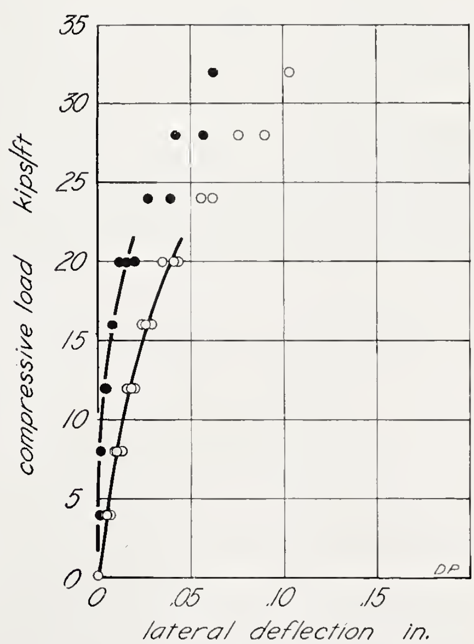


FIGURE 8.—*Compressive load on wall DP.*

Load-lateral deflection (open circles) and load-lateral set (solid circles) results for specimens *DP–C1*, *C2*, and *C3*. The load was applied 1.92 in. (one-third the thickness of the wall) from the inside face. The loads are in kips per foot of actual width of specimen. The deflections and sets are for a gage length of 7 ft. 6 in., the gage length of the deflectometers.

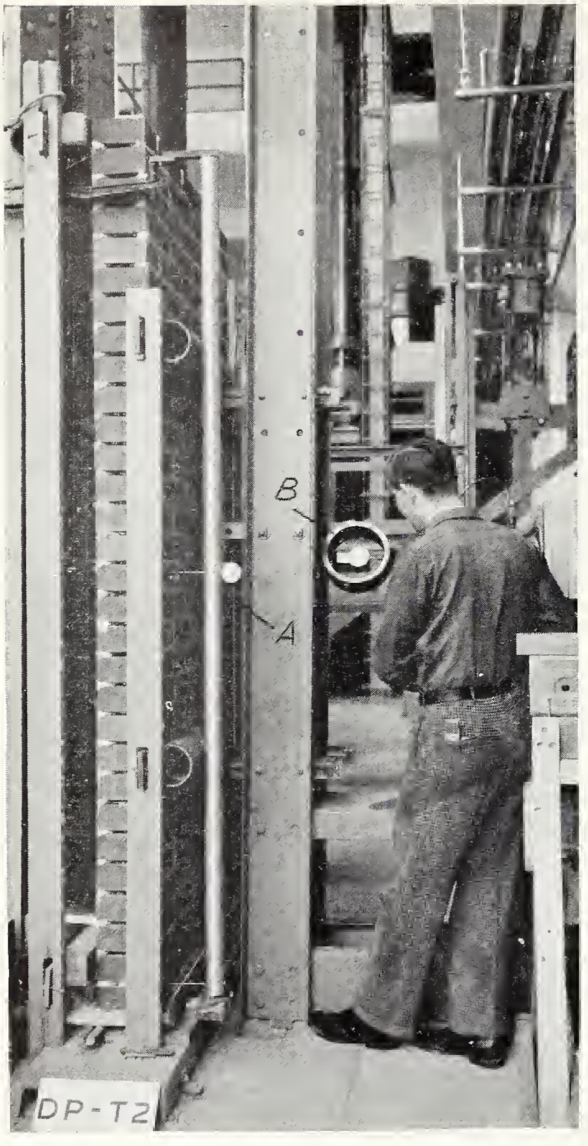


Figure 9.—*Wall specimen DP–T2 under transverse load.*

A, deflectometer; *B*, ring dynamometer.

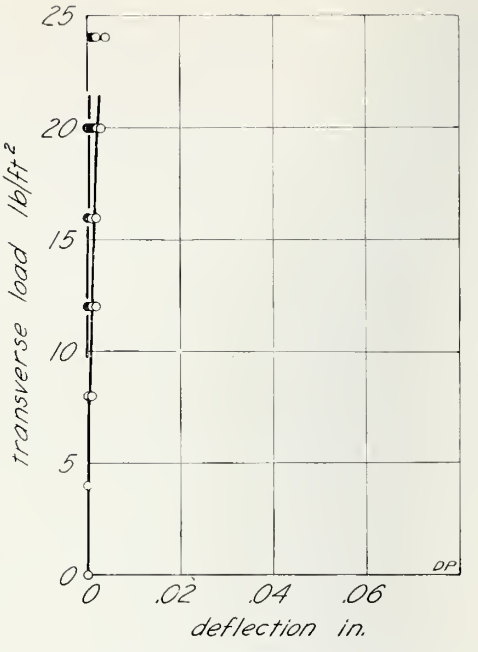


Figure 10.—*Transverse load on wall DP.*

Load-deflection (open circles) and load-set (solid circles) results for specimens *DP–T1, T2,* and *T3* on the span 7 ft. 6 in.

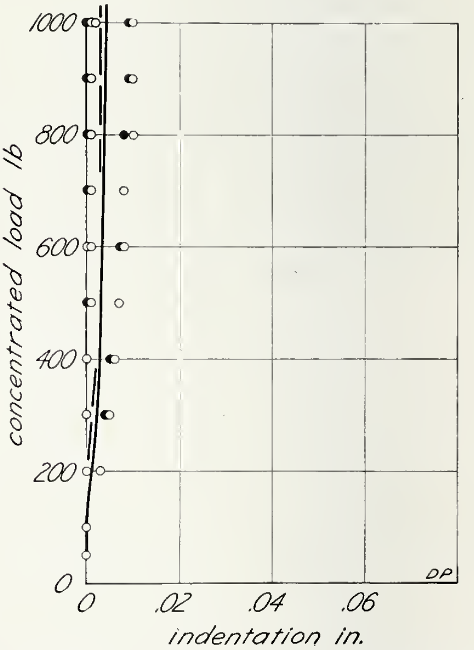


Figure 11.—*Concentrated load on wall DP.*

Load-indentation (open circles) and load-set (solid circles) results for specimens *DP–P1, P2,* and *P3.*

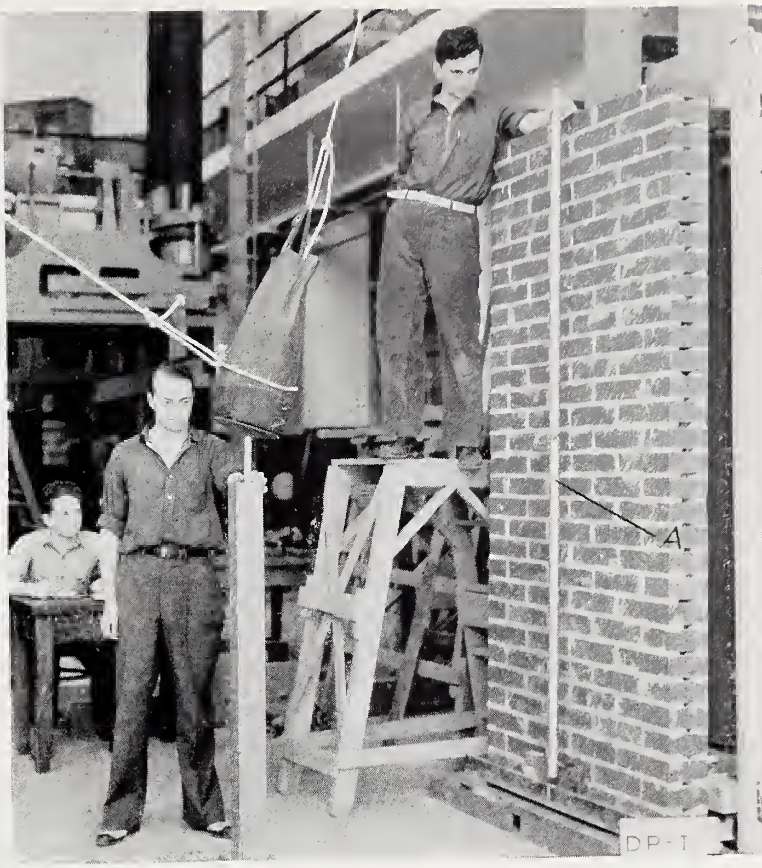
7. Racking Load

Wall specimen *DP–R3* under racking load is shown in figure 14. The results of the racking loads on specimens *DP–R1, R2,* and *R3* are shown in table 6 and in figure 15.

The racking load was applied to one edge of each specimen at midthickness 6 in. below the top. The stop was in contact with the edge of the specimen at the diagonally opposite corner. Under the maximum load on each specimen, the bond between the units and the mortar ruptured in stepwise cracks through the bed and head joints diagonally from the load to the stop. The crack passed through several units in each specimen.

Figure 12.—*Wall specimen DP-I1 during the impact test.*

A, gage for measurement of set.



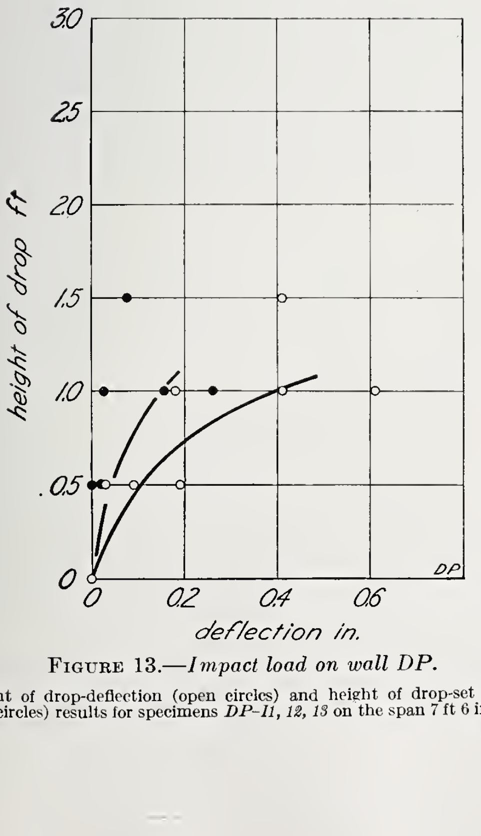


Figure 13.—*Impact load on wall DP.*

Height of drop-deflection (open circles) and height of drop-set (solid circles) results for specimens *DP-I1, 12, 13* on the span 7 ft 6 in.

Specimen *DP-R2* after test is shown in figure 16.

V. HEAT-TRANSFER PROPERTIES

The heat-transfer specimens, *HT51* and *HT52*, were similar in construction to the structural specimens. Specimen *HT51* was built of 8-in. units, not 6-in. units. This specimen, shown in figure 17, was 8 ft 1⅝ in. high. 4 ft 7⅝ in. wide, and 7¾ in. thick.

Specimen *HT52* was built of 6-in. units and was 8 ft 1⅝ in. high, 4 ft 7$\frac{9}{16}$ in. wide, and 5¾ in. thick.

The top of each specimen was finished with a mortar cap to close the cells.

The results of the heat-transfer tests are presented in table 7. The transmittance (*U*) of these specimens may be compared with the value 0.50 given in the ASHVE Guide for 8-in. solid brick walls, hard brick face, common brick backing.

FIGURE 14.—*Wall specimen DP-R3 under racking load.*

A, deformeter.

TABLE 7.—*Heat-transfer coefficients for walls HT51 and HT52*

Item	*HT51*, 8-in. wall	*HT52*, 6-in. wall
Observed thermal transmittance, u	0.36	0.40
Corrected thermal transmittance, U	.42	.48
Thermal conductance, C	.61	.76
Warm surface film coefficient, fi	1.83	1.83
Cold surface film coefficient, fo	1.63	1.59
Temperature averages:		
Warm side:	°F	°F
Air	70.5	70.3
Surface	56.7	54.7
Cold side:		
Air	+0.2	−1.1
Surface	15.7	17.1
Temperature differences:		
Air to air	70.3	71.3
Surface to surface	41.0	37.6
Surface to air, warm	13.8	15.6
Surface to air, cold	15.5	18.1
Mean of air temperatures	35.3	34.6
Mean wall temperature	36.2	35.9

NOTE.—The definitions of u, U, and C, representing the various coefficients of heat transmission, are as follows:

u equals the number of Btu per hour transmitted through each square foot of specimen for each degree F difference in temperature between the air on the two sides, observed under test conditions.

U equals u corrected for a 15-mile-per-hour wind outside and zero wind inside by means of the factors $fi=1.65$ and $fo=6.00$, taken from the ASHVE Guide.

C equals the number of Btu per hour transmitted through each square foot of specimen for each degree F difference in temperature between the surfaces of the two sides, observed under test conditions.

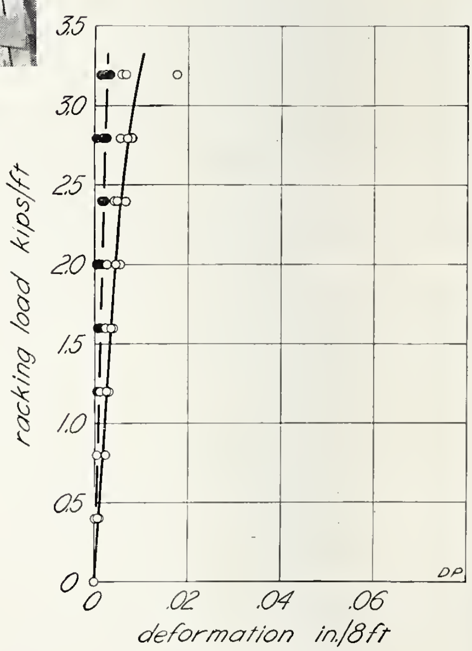


FIGURE 15.—*Racking load on wall DP.*

Load-deformation (open circles) and load-set (solid circles) results for specimens *DP-R1, R2,* and *R3.* The loads are in kips per foot of actual width of specimen.

Figure 16.—*Wall specimen DP–R2 after racking test.*

VI. WATER-PERMEABILITY PROPERTIES

1. Materials

(*a*) *Masonry Units*

The masonry units for water-permeability specimens were in thicknesses of 4,6, and 8 in. The 6-in. specimens were constructed at the same time as the structural specimens. The 8- and 12-in. specimens were constructed in January 1939. The physical properties of the 8-in. units are given in table 8.

Table 8.—*Physical properties of 8-in. units, used in water-permeability specimens*

Property	Tennessee units	Ohio units
Average dimensions:		
Thickness ... in.	7.9	7.9
Width ... in.	12.0	11.9
Length ... in.	2.8	2.7
Average dry weight ... lb	12.3	12.9
Absorption:		
By total immersion:		
24-hr. cold, C ... % by dry weight	3.6	1.5
5-hr. boiling, B ... % by dry weight	6.6	2.8
By partial immersion [a] ... g/30 in.^{2}	20	6
Saturation coefficient, C/B	0.55	0.54
Compressive strength ... lb/in.^{2}	(b)	(b)

[a] Immersed on flat side in ⅛ in. of water for 1 minute.
[b] Greater than 6,500 lb/in.^{2}.

(*b*) *Mortar*

The water-permeability specimens were bonded with three different mortars, desig-

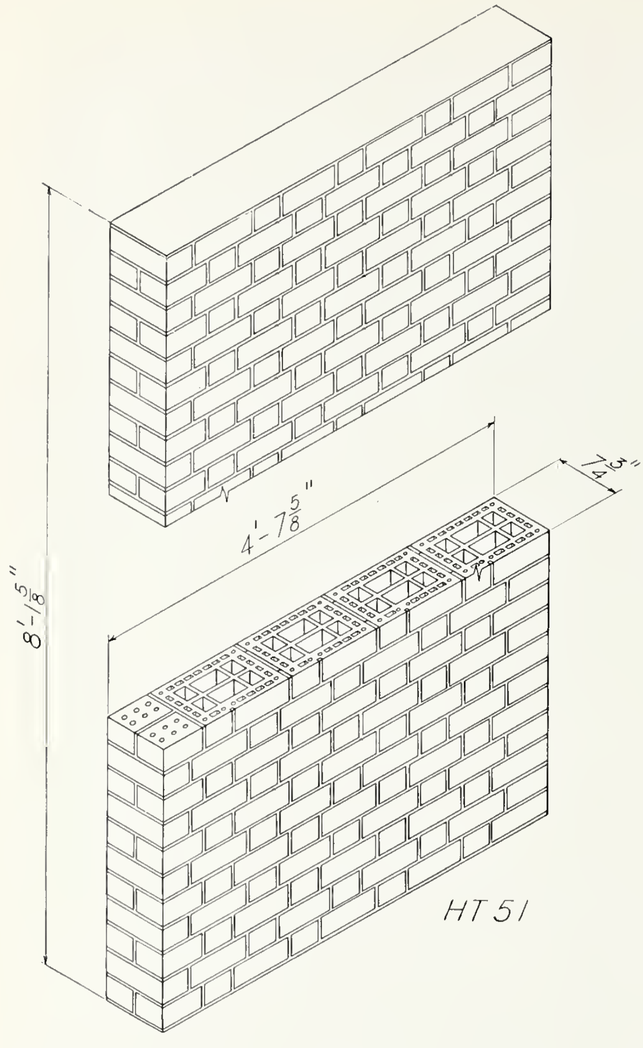


FIGURE. 17—*Heat-transfer wall HT51.*

nated as 7, 8, and 12. Mortars 7 and 8 contained portland cement, lime, limestone dust, and sand. Mortar 12 contained no limestone dust and was the same as for the structural and heat-transfer specimens.

The cement and lime combinations are indicated in table 9. The limestone dust was H. T. Campbell Sons Co.'s "Cameline Brand," and the sand for mortars 7 and 8 was Potomac River building sand. The sieve analysis is given in table 10.

TABLE 9.—*Physical properties of mortar, water-permeability specimens*

Mortar: Number	Mortar: Proportions	Portland cement	Lime	Water content, by weight of materials	Average initial flow	Water retentivity
				Percent	*Percent*	*Percent*
7:						
By volume	1 : 0.3 : 0.15 : 3.4	"Medusa" waterproof	"Standard" dry hydrate	19.5	116	60
By weight	1 : 0.13 : 0.13 : 2.9					
8:						
By volume	1 : 1.0 : 0.6 : 5.9	"Medusa" waterproof	"Washington" putty [b]	21.5	97	89
By weight	1 : 0.42 : 0.51 : 5.1					
12: [c]						
By volume	1 : 1.0 : 0.0 : 6.0	"Greenbag"	"Grove's" dry hydrate	21.1	119	64
By weight	1 : 0.42 : 0.0 : 5.1					

[a] These proportions represent portland cement, lime, limestone dust, and sand, respectively.
[b] Slaked powdered quicklime.
[c] Mortar 12 contained no limestone dust.

TABLE 10.—*Sieve analysis of the sand, water-permeability specimens*

U. S. Standard Sieve No.	Passing, by weight
	Percent
8	100
16	96
30	73
50	18
100	2

2. Description of Specimens

The water-permeability specimens were about 50 in. high, 42 in. wide, and 6, 8, or 12 in. thick, depending on the units in the specimen. They were supported on a single course of common brick resting on a steel channel. The brick course contained a copper flashing so that water penetrating the specimen could be collected and the rate of flow measured.

Except for differences in dimensions of units and specimens, the water-permeability and structural specimens were constructed in the same manner; they were aged at least 1 month before being tested.

3. Test Procedure

The water-permeability test is described in BMS7, Water-Permeability of Masonry Walls, as the "heavy rain test." The specimens were supported on metal skids and clamped into position so that the exposed face formed one side of a pressure chamber. An air pressure of 10 lb/ft^2 above atmospheric was maintained in the chamber, and water from a perforated tube was sprayed at the top of the exposed face at the rate of 40 gal/hr for the duration of the test. Continual observations were made for about 2 hours after starting the test, after which the observer inspected the specimens at frequent intervals.

The following observations were made during the test: Time required for the appearance of moisture (dampness) and of visible water on the back of a specimen above the flashings; time required for the leakage of water from the flashing at the back of a specimen and the maximum rate of leakage; extent of damp area on the back, including that due to the capillary rise of moisture from water on the flashings.

The ratings of performance are arbitrary and are based on the assumption that visible water, extensive damp areas on the back, or leakage through a wall would damage plaster applied directly to the wall or would injure the finished interior of a building. The following ratings were applied:

Excellent (E): No visible water on back of specimen (above the flashings) in 1 day. No leaks and not more than 25 percent of face area damp in 5 days. (A leak is defined as a flow of water from the flashings of 0.05 liter/hr or more.).

Good (G): No visible water on back of specimen in 1 day. No leaks and less than 50 percent of face area damp in 1 day.

Fair (F): Visible water on back of specimen in more than 3 hours or less than 24 hours. Maximum rate of leakage less than 1 liter/hr in 1 day.

Poor (P): Visible water on back of specimen in 3 hours or less. Maximum rate of leakage less than 5 liters/hr in 1 day.

Very poor (VP): Maximum rate of leakage 5 liters/hr or more in 1 day.

4. Test Results

Data obtained from the water-permeability tests are given in table 11. All the walls failed by water penetrating the face, dropping through the vertical cells of the units, and coming through the back of the specimen at the flashing, where it was measured.

TABLE 11.—*Water-permeability test data*

Source of unit	Specimen thickness	Mortar No.	Time to failure as indicated by— Dampness [a]	Visible water [a]	Leak	Maximum rate of leakage	Area damp in 1 day	Rating
	In.		*Hr*	*Hr*	*Hr*	*Liters/hour*	*Percent*	
Ohio	8	8	------	------	[b] 18±3	0.02	0	*E*
Do	8	8	------	------	0.5	.25	0	*F*
Tennessee	8	7	[b] 39±6	------	.4	.9	4	*F*
Do	8	7	6.4	------	.3	2.4	5	*P*
Do	8	7	5.4	------	.5	0.8	4	*F*
Do	12	7	------	------	.2	3.0	5	*P*
Do	6	12	2.4	------	2.7	0.7	70	*F*
Do	6	12	0.2	------	0.8	2.8	75	*P*
Do	6	12	1.8	------	4.3	0.4	40	*F*

[a] A dash indicates wall did not fail in this manner.
[b] The uncertainty of the observation is given only if it exceeds 10 percent of the total elapsed time.

The 6-in. walls had considerable dampness on the back, whereas walls of similar 8-in. units had only about one-twelfth the damp area. The

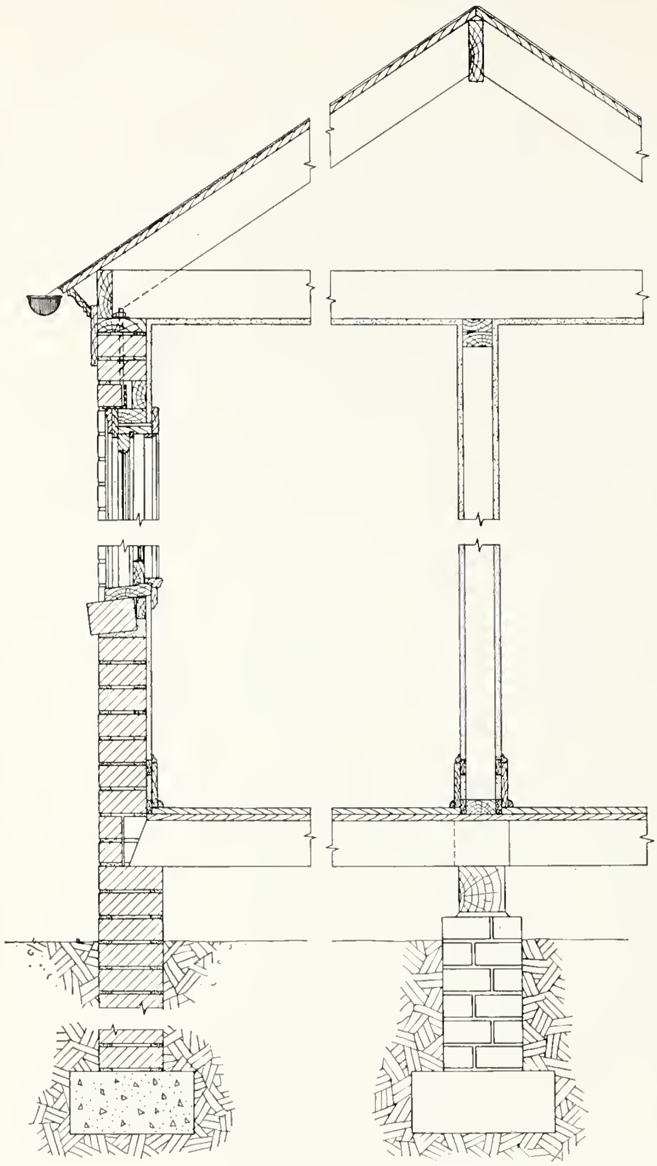


Figure 18.—*Typical details of a house of "Speedbrik" units.*

8-in. walls made of Ohio units were less permeable than the 8-in. walls of Tennessee units, probably due to the fact that the Ohio units had a lower brick suction (absorption) and were laid with mortar of a higher water retentivity.

VII. COMMENTS

"Speedbrik" units are available in thicknesses of 3, 4, 6, and 8 in. Masonry cavity walls of greater thicknesses are built of combinations of these four sizes. Special units are provided to accommodate steel-sash frames. Closure blocks are used for fillers around window and door openings and water tables.

The units are laid with the cells vertical to provide thermal insulation and resistance to moisture penetration.

Pointed false joints in grooves on the faces of the units give the wall the appearance of Flemish bond. Other styles of "Speedbrik" have grooves in the face and one end of the unit, so that other bonds may be imitated in a wall of single-unit thickness.

Plaster may be applied to the inside wall surface with no lath or furring strips.

Typical framing details are shown in figure 18.

The drawings of the specimens were prepared by E. J. Schell and G. W. Shaw, of the Building Practices and Specifications Section of this Bureau, under the supervision of V. B. Phelan.

The physical properties of the units and the mortar and the water-permeability properties of the walls were determined by the Masonry Construction Section, under the supervision of D. E. Parsons.

The structural properties were determined by the Engineering Mechanics Section, under the supervision of H. L. Whittemore.

The heat-transfer properties of the specimens were determined by H. E. Robinson, of the Heat Transfer Section, under the supervision of R. S. Dill.

The following members of the professional staff assisted: E. S. Cohen, A. H. Easton, W. G. Hoback, L. R. Sweetman, and H. L. Weiss.

Washington, May 8, 1942.

BUILDING MATERIALS AND STRUCTURES REPORTS

[Continued from cover page II]

BMS31	Structural Properties of "Insulite" Wall and "Insulite" Partition Construction Sponsored by The Insulite Co	15¢
BMS32	Structural Properties of Two Brick-Concrete-Block Wall Constructions and a Concrete-Block Wall Construction Sponsored by the National Concrete Masonry Association	10¢
BMS33	Plastic Calking Materials	10¢
BMS34	Performance Test of Floor Coverings for Use in Low-Cost Housing: Part 1	10¢
BMS35	Stability of Sheathing Papers as Determined by Accelerated Aging	10¢
BMS36	Structural Properties of Wood-Frame Wall, Partition, Floor, and Roof Constructions with "Red Stripe" Lath Sponsored by the Weston Paper and Manufacturing Co	10¢
BMS37	Structural Properties of "Palisade Homes" Constructions for Walls, Partitions, and Floors, Sponsored by Palisade Homes	10¢
BMS38	Structural Properties of Two "Dunstone" Wall Constructions Sponsored by the W. E. Dunn Manufacturing Co	10¢
BMS39	Structural Properties of a Wall Construction of "Pfeifer Units" Sponsored by the Wisconsin Units Co	10¢
BMS40	Structural Properties of a Wall Construction of "Knap Concrete Wall Units" Sponsored by Knap America, Inc	10¢
BMS41	Effect of Heating and Cooling on the Permeability of Masonry Walls	10¢
BMS42	Structural Properties of Wood-Frame Wall and Partition Constructions with "Celotex" Insulating Boards Sponsored by The Celotex Corporation	15¢
BMS43	Performance Test of Floor Coverings for Use in Low-Cost Housing: Part 2	10¢
BMS44	Surface Treatment of Steel Prior to Painting	10¢
BMS45	Air Infiltration Through Windows	10¢
BMS46	Structural Properties of "Scot-Bilt" Prefabricated Sheet-Steel Constructions for Walls, Floors, and Roofs Sponsored by The Globe-Wernicke Co	10¢
BMS47	Structural Properties of Prefabricated Wood-Frame Constructions for Walls, Partitions, and Floors Sponsored by American Houses, Inc	10¢
BMS48	Structural Properties of "Precision-Built" Frame Wall and Partition Constructions Sponsored by the Homasote Co	10¢
BMS49	Metallic Roofing for Low-Cost House Construction	10¢
BMS50	Stability of Fiber Building Boards as Determined by Accelerated Aging	10¢
BMS51	Structural Properties of "Tilecrete Type A" Floor Construction Sponsored by the Tilecrete Corporation	10¢
BMS52	Effect of Ceiling Insulation upon Summer Comfort	10¢
BMS53	Structural Properties of a Masonry Wall Construction of "Munlock Dry Wall Brick" Sponsored by the Munlock Engineering Co	10¢
BMS54	Effect of Soot on the Rating of an Oil-Fired Heating Boiler	10¢
BMS55	Effects of Wetting and Drying on the Permeability of Masonry Walls	10¢
BMS56	A Survey of Humidities in Residences	10¢
BMS57	Roofing in the United States—Results of a Questionnaire	10¢
BMS58	Strength of Soft-Soldered Joints in Copper Tubing	10¢
BMS59	Properties of Adhesives for Floor Coverings	10¢
BMS60	Strength, Absorption, and Resistance to Laboratory Freezing and Thawing of Building Bricks Produced in the United States	15¢
BMS61	Structural Properties of Two Nonreinforced Monolithic Concrete Wall Constructions	10¢
BMS62	Structural Properties of a Precast Joist Concrete Floor Construction Sponsored by the Portland Cement Association	10¢
BMS63	Moisture Condensation in Building Walls	10¢
BMS64	Solar Heating of Various Surfaces	10¢
BMS65	Methods of Estimating Loads in Plumbing Systems	10¢
BMS66	Plumbing Manual	20¢
BMS67	Structural Properties of "Mu-Steel" Prefabricated Sheet-Steel Constructions for Walls, Partitions, Floors, and Roofs Sponsored by Herman A. Mugler	15¢
BMS68	Performance Test of Floor Coverings for Use in Low-Cost Housing: Part 3	15¢
BMS69	Stability of Fiber Sheathing Boards as Determined by Accelerated Aging	10¢
BMS70	Asphalt-Prepared Roll Roofings and Shingles	15¢
BMS71	Fire Tests of Wood and Metal Framed Partitions	10¢
BMS72	Structural Properties of "Precision-Built, Jr." Prefabricated Wood-Frame Wall construction Sponsored by the Homasote Co	10¢
BMS73	Indentation Characteristics of Floor Coverings	10¢
BMS74	Structural and Heat-Transfer Properties of "U. S. S. Panelbilt" Prefabricated Sheet-Steel Constructions for Walls, Partitions, and Roofs Sponsored by the Tennessee Coal, Iron, and Railroad Co	15¢
BMS75	Survey of Roofing Materials in the North Central States	15¢
BMS76	Effect of Outdoor Exposure on the Water Permeability of Masonry Walls	15¢
BMS77	Properties and Performance of Fiber Tile Boards	10¢
BMS78	Structural, Heat-Transfer, and Water-Permeability Properties of Five Earth-Wall Constructions	20¢
BMS79	Water-Distributing Systems for Buildings	15¢
BMS80	Performance Tests of Floor Coverings for Use in Low-Cost Housing: Part 4	15¢
BMS81	Field Inspectors' Check List for Building Construction, (cloth cover, 5 x 7½ inches)	20¢
BMS82	Water Permeability of Walls Built of Masonry Units	20¢
BMS83	Strength of Sleeve Joints in Copper Tubing Made with Various Lead-Base Solders	10¢
BMS84	Survey of Roofing Materials in the South Central States	15¢
BMS85	Dimensional Changes of Floor Coverings with Changes in Relative Humidity and Temperature	10¢
BMS86	Structural, Heat-Transfer, and Water-Permeability Properties of "Speedbrik" Wall Construction	15¢